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Level 1 Product Generation System (LPGS) Critical Design Review

August 19, 1997

LPGS Critical Design Review

Agenda

■ Opening Comments	J. Henegar
■ System Overview	R. Hamilton
■ Hardware Architecture	K. Jeletic
■ Operational Scenarios	K. Jeletic
■ Level 1 Product Formats	L. Lindrose
■ Performance Analysis	W. Wang
■ LPGS Software Subsystem Design	
• Design Overview	B. Pedersen
• End-to-End Scenarios	B. Pedersen
• User Interface	O. Mechaly
• Data Management Subsystem	S. Beckwell
• Process Control Subsystem	B. Pedersen
• Radiometric and Geometric Processing Subsystems	B. Pedersen
• Quality Assessment Subsystem	S. Kraft
• Anomaly Analysis Subsystem	B. Nair
■ System Test	E. Crook
■ Conclusion	J. Henegar

LPGS Critical Design Review

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LPGS Critical Design Review

Purpose of Review

- Present synopsis of LPGS detailed design
- Scope of LPGS detailed design
  - Defined detailed design for software and hardware CIs
  - Refined detailed intersubsystem interfaces and external interfaces
  - Defined detailed design for operator-system interface
  - Defined detailed design for database
  - Refined operations scenarios
  - Performed further studies and prototypes to guide design
  - Defined final test plans
  - Documented the above in specifications, ICDs, plans, etc.

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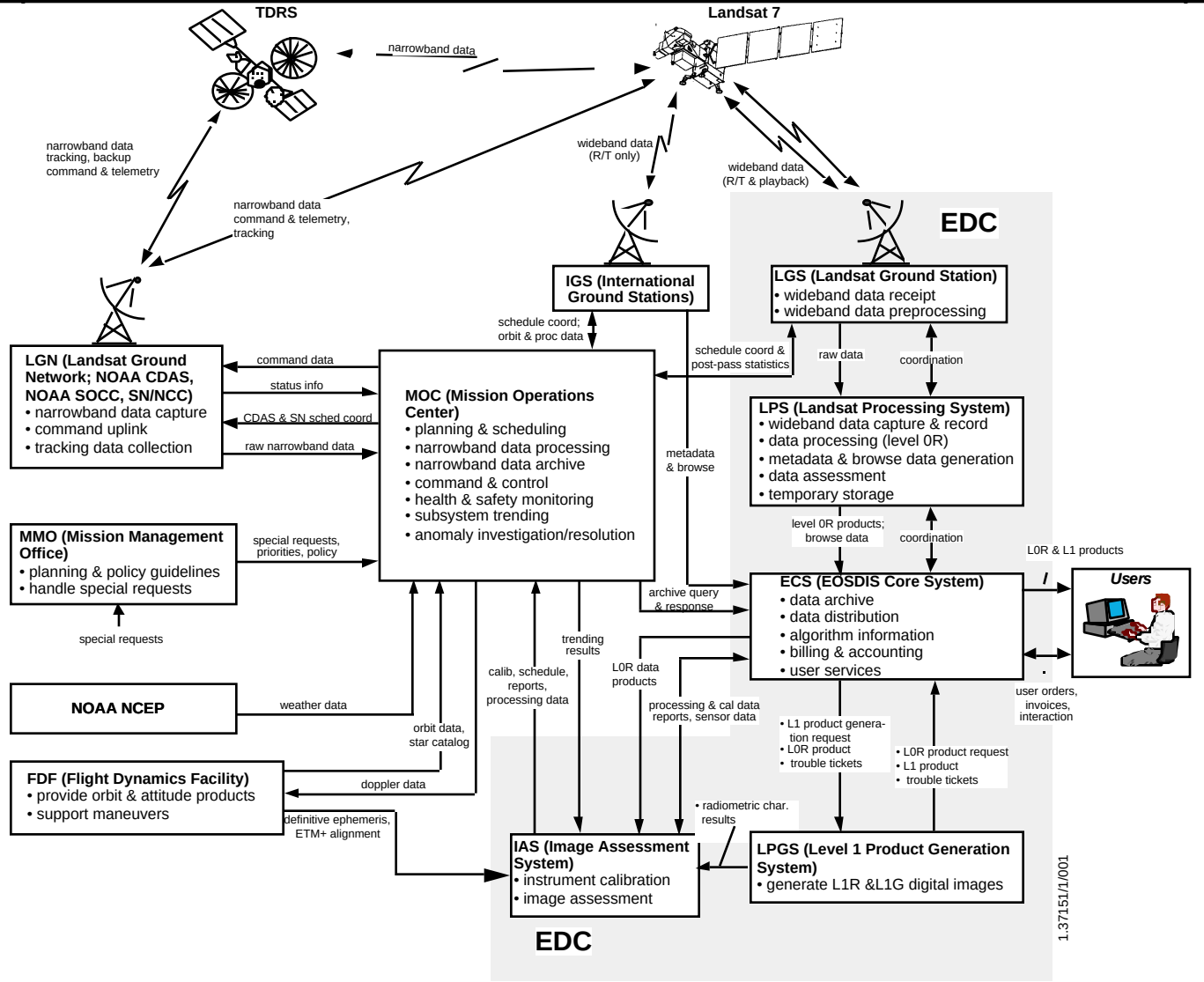
LPGS Critical Design Review

Landsat 7 Ground System Overview



LPGS Critical Design Review

LPGS Technical Review Panel

- Ludie Kidd—L7 Implementation Manager Cochair
- Dan Marinelli—ESDIS-L7 System Engineer Cochair
- Jim Andary—L7 System Manager
- Jeff Pedelty—Project Science Office Representative
- Shaida Johnston—IAS System Engineer
- Robert Schweiss—LPS System Engineer
- Darla Werner—EDC L7 Ground System Manager
- Jim Ellickson—NOAA Representative
- Lyn Oleson—EDC DAAC Representative

LPGS Critical Design Review

LPGS Documentation

- **Accompanying documentation**
  - **LPGS Detailed Design Specification**
  - **LPGS Interface Definitions Documentation**
  - **LPGS System Integration and Test Plan**
  - **LPGS Release Implementation Plan**
  - **LPGS User's Guide (Preliminary)**
  - **LPGS Output Files Data Format Control Book**
- **Reference documentation**
  - **IAS-LPGS Interface Control Document**
  - **ECS-LPGS Interface Control Document**
  - **Landsat 7 System Data Format Control Book, Volume 5, Book 1, Level Zero R Distribution Product**

LPGS Critical Design Review

Online Documentation

- **All LPGS documentation and presentations are available on the LPGS web server:**

http://lpgs-server.gsfc.nasa.gov

LPGS Critical Design Review

RID Process

- **Submit RIDs to Joy Henegar no later than September 5, 1997**
  - **Submit RIDs by e-mail (preferred method):**

    joy.henegar@gsfc.nasa.gov

    or by hardcopy (RID form provided):

    J. Henegar
    Code 514
  - **For an e-mail submission, make sure all required information is provided (see RID hardcopy form)**
- **Items against which RIDs may be written**
  - **Presentation package**
  - **LPGS accompanying documentation**

LPGS Critical Design Review

LPGS SRR/SDR Followup

- 22 RIDs were received from SRR/SDR in December
- All SRR/SDR RIDs have been closed

LPGS Critical Design Review

RID Summary—Hardware Architecture

- Concerns with SRR/SDR architecture being I/O bound
- Requests for clarifications on sizing and worst case analysis
- Resolution
  - Revised architecture was presented to SRR/SDR review panel chairs in February and approved
  - Architecture and performance/sizing analysis are discussed later in this presentation

LPGS Critical Design Review

RID Summary—L1 Product Contents/Assembly

- SRR/SDR presented contents and assembly as follows:
  - L1 digital image — LPGS
  - Production quality information — LPGS
  - Calibration parameter file (CPF) — ECS
  - Payload correction data (PCD) (L1R only) — ECS
  - Mirror scan correction data (MSCD) (L1R only) — ECS
  - Internal calibrator (IC) data (L1R only) — ECS
  - Metadata — LPGS
- SRR/SDR also assumed that PCD and MSCD for each format was packaged in final product
- Resolution
  - LPGS will provide all components of L1 products to ECS
  - LPGS will provide consensus PCD and MSCD files where appropriate
  - Details of data product contents are discussed later in this presentation

LPGS Critical Design Review

RID Summary—Prioritization Scheme

- SRR presented requirements that LPGS be a FIFO batch system with a mechanism for operator to move work orders within production queue
- Several RIDs were received on providing a more sophisticated prioritization scheme
- Resolution
  - LPGS will remain a FIFO batch system as documented for the SRR/SDR
  - LPGS will continue to provide a mechanism for operator to move work orders within production queue
  - ECS provides prioritization functions that will be used prior to work orders being accessed by LPGS
  - Overview of end-to-end prioritization is discussed later in this presentation

LPGS Critical Design Review

LPGS Design Changes Since CDR Freeze

- **Some ECS interface design protocols and terminology were finalized after design freeze**
  - **Changes are isolated to one area of design**
  - **Review version of ECS-LPGS ICD reflects up-to-date understanding of interface**
  - **Finalized interface protocols will allow more reuse on both sides of interface**
  - **LPGS design will be updated after CDR**
- **Some user interface screens were finalized after design freeze, based on EDC operations feedback**
  - **In mid July, user interface design was presented to EDC operations personnel at EDC**
  - **Feedback from meeting has not been fully incorporated into design. Design will be updated after CDR**
  - **Meetings with EDC personnel to walk through user interface are planned, and prototyping of user interface is being explored**

LPGS Critical Design Review

LPGS Design Assumptions

- **Network connectivity between LPGS and IAS**
  - **LPGS design assumes that IAS can access LPGS database for retrieval of characterizations, etc.**
  - **Network configuration has not been finalized**
  - **Network connectivity changes could result in interface as designed requiring modifications**
- **COTS product for FAST-C formatting**
  - **LPGS design assumes COTS product will be available for FAST-C formatting**
  - **Currently no COTS product exists for this function, although one vendor is indicating that such a product will be available in 6 months**
  - **FAST-C formatting will be scheduled for Release 2 implementation. If COTS product is not available at that time, LPGS will need to investigate developing custom tool to provide this function**

LPGS Critical Design Review

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LPGS Critical Design Review

System Overview

- Purpose of LPGS
- System design drivers
- System concept
- High-level requirements
- Changes since SRR/SDR
- External interfaces
  - ECS
  - IAS

LPGS Critical Design Review

Purpose of LPGS

- **Provide Landsat 7 user community with radiometrically corrected (L1R) and geometrically corrected (L1G) digital products**

LPGS Critical Design Review

System Design Drivers

- Reuse IAS elements to minimize new development and duplication
- Integrate and test both radiometric and geometric processing subsystems as black boxes
- Must generate 25 WRS scenes per day
- Must interface with ECS and IAS

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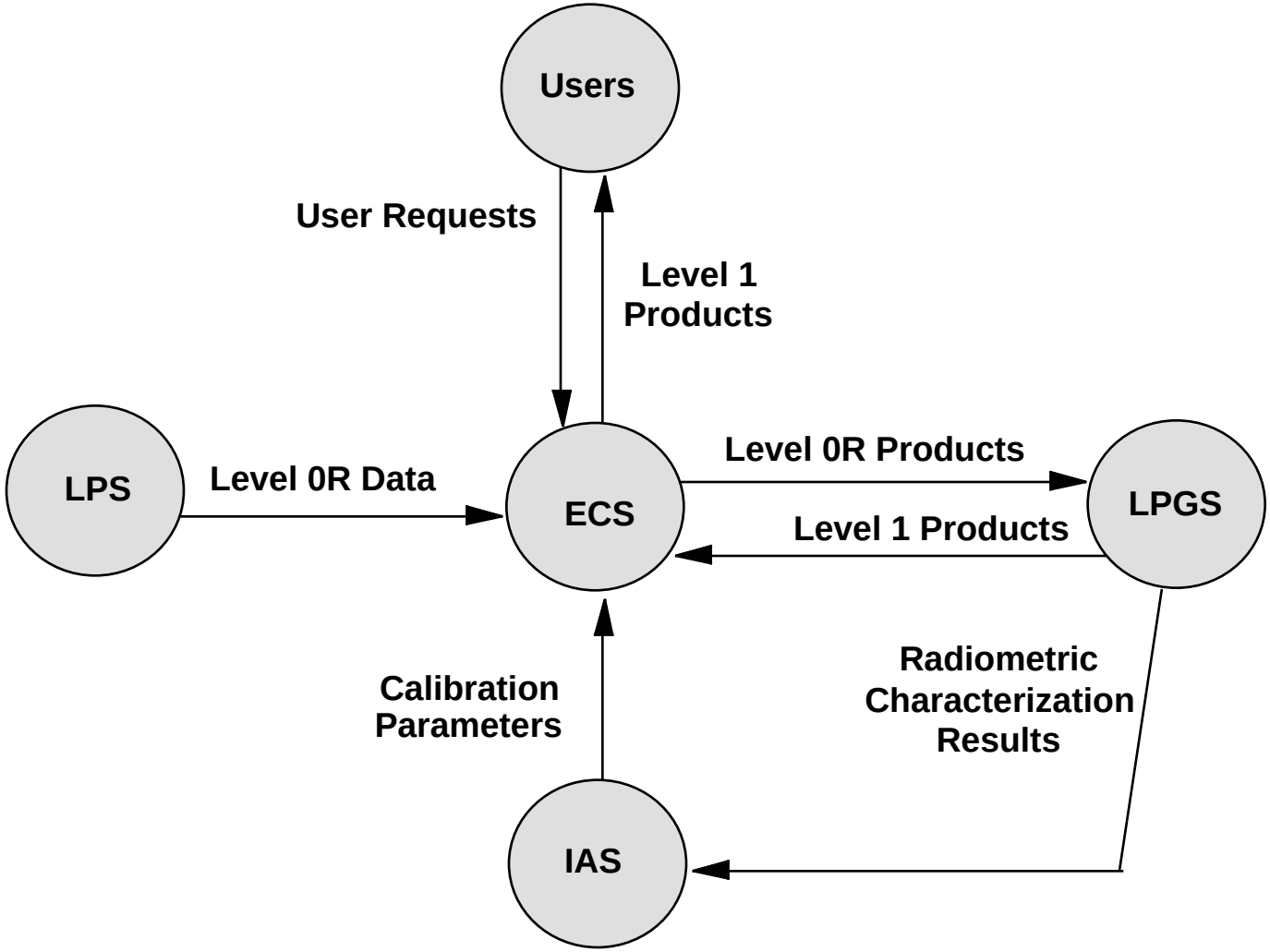
LPGS Critical Design Review

System Concept



LPGS Critical Design Review

High-Level Requirements

- Generate 25 WRS scenes per day to Level 1 radiometric correction (L1R) or to Level 1 geometric correction (L1G)
- Support user-selectable processing options
  - Map projection (7)
  - Orientation (North up or orbital path)
  - Resampling method (CC, NN, and MTF)
  - Grid cell size (variable from 15M to 60M at .001M increments)
  - Band selection (all 8 or a subset)
  - Product choice (L1R or L1G)
- Apply compensation for image artifacts
  - Banding, striping, coherent noise, memory effect, scan correlated shift, and inoperable detectors

LPGS Critical Design Review

High-Level Requirements (Cont'd)

- Support 3 output formats
  - HDF-EOS unencapsulated (L1R and L1G)
  - GeoTIFF (L1G only)
  - FAST (L1G only)
- Process scenes by
  - Standard WRS
  - Floating scene (within path only; no mosaics)
- Provide quality assessment and visual display of products
- Provide offline analysis of image processing problems
- Interface with ECS
  - To receive product requests and L0R data
  - To deliver L1 data
- Interface with IAS to transfer radiometric characterization results

LPGS Critical Design Review

Changes Since SRR/SDR

- **LPGS will now**
  - **Perform product quality assessment after L1 product formatting (SDR RID #6)**
  - **Package MSCD, PCD, and calibration data in final product versus ECS (SDR RID #8)**
  - **Provide option for user to select internal calibrator or calibration parameter data for processing (SDR RID #9)**
  - **Select a consensus PCD and MSCD to include in final product (SDR RID #10)**

LPGS Critical Design Review

Changes Since SRR/SDR (Cont'd)

- **Other changes**
  - **Deleted scan correlated shifts and memory effects from listing of image artifacts that LPGS will detect and characterize (SDR RID #14)**
  - **Clarified that LPGS optionally will be able to print color hardcopy of any band display (SDR RID #15-7)**
  - **Modified system availability requirement from .95 to .96 and MTTR from 16 hours to 4 hours to align with other ground support systems (e.g., LPS) (SDR RID #19)**
  - **Added requirement to "control system aborts in a manner where the operator would retain system recovery features" (SDR RID# 21)**

LPGS Critical Design Review

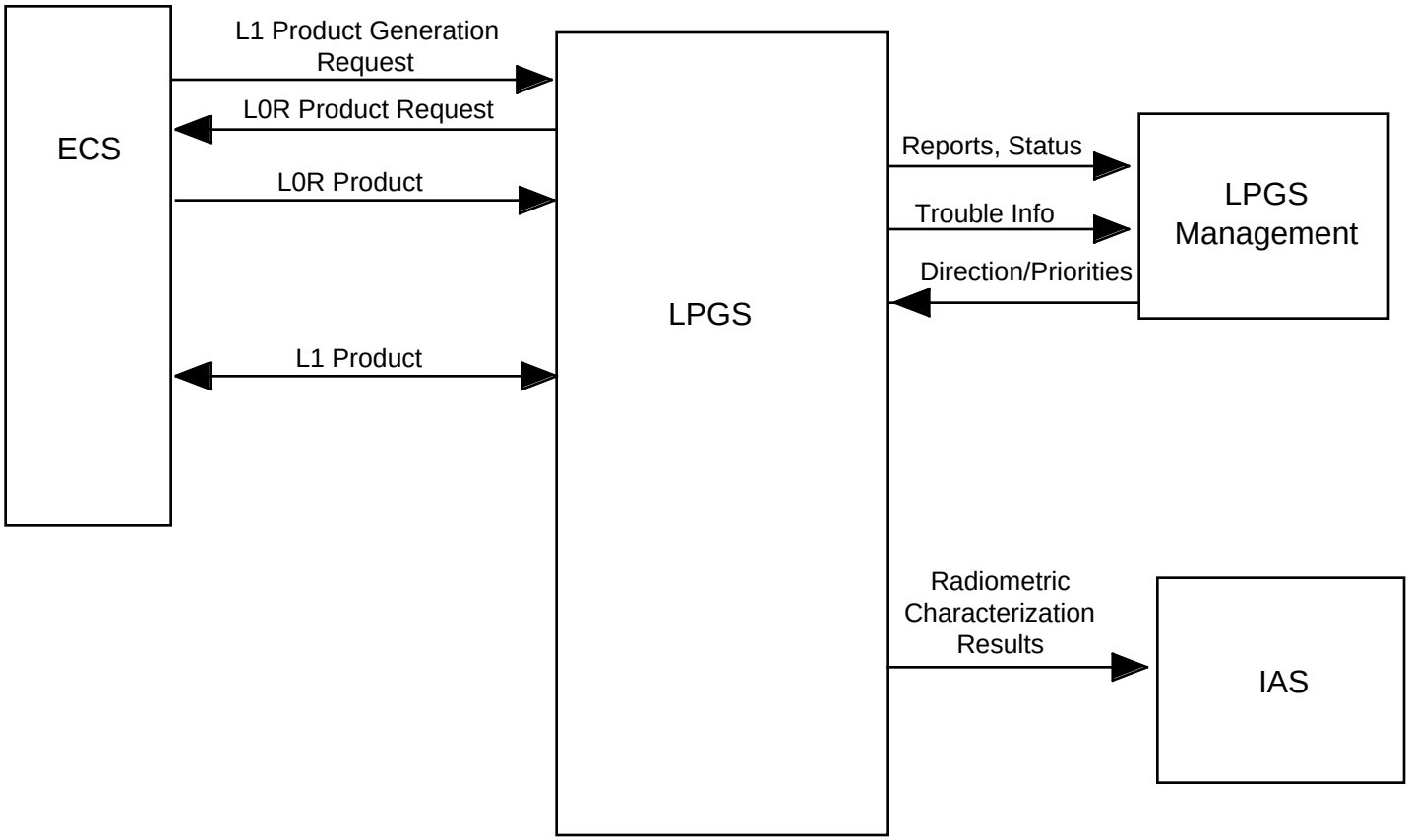
Changes Since SRR/SDR (Cont'd)

- **Other changes (cont'd)**
  - **Modified requirement to hold all output products for 72 hours after retrieval by ECS; after ECS pulls product to their server and provides verification of receipt, product can be deleted from LPGS servers**
  - **Deleted problem reporting interface with DHF**
  - **Scene size to range from .5 to 3 WRS scene equivalents versus .25 to 3 WRS scene equivalents**

LPGS Critical Design Review

External Interfaces

LPGS INTERFACES (Simplified)



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ECS External Interface

- **ECS interface**
  - **Being finalized (ICD in draft)**
  - **Based on assumptions memo from A. Bernard (6/6/97) and meetings with ECS**
    - **Network connectivity through the EDC Exchange LAN**
    - **TCP/IP**
    - **ftp**

LPGS Critical Design Review

IAS External Interface

- **IAS interface**
  - **Documented in draft IAS-LPGS ICD dated June 20, 1997**
  - **Based on assumption that IAS will access LPGS database through SQL*Net to obtain L1 radiometric processing characterization results and will update a deletion flag**
  - **Final network connectivity between IAS and LPGS to be determined**
    - **EDC Exchange LAN connectivity to IAS currently assumed**

LPGS Critical Design Review

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LPGS Critical Design Review

Hardware Architecture

- Changes since SRR/SDR
- Functional overview
- Current architecture

LPGS Critical Design Review

Changes Since SRR/SDR

- Architecture modified due to I/O performance considerations
- Image processing centralized on SGI Origin 2000 server to limit data moves
- Offline analysis supported by SGI 02 workstation
- Development and Test supported by a backup Origin 2000
- RAID disk array to provide data storage
- Color printer to be EDC institutional equipment; type TBD

LPGS Critical Design Review

Functional Overview

- Major functions of LPGS hardware
  - Performs L1 processing
  - Provides data storage for production control database
  - Provides temporary storage for ingesting incoming L0R products and for outgoing L1 products
- Two ‘strings’
  - Operations system
  - “Test” system
    - Is used for software maintenance and testing
    - Can be used as backup system
  - Configurations vary (memory, disk space)

LPGS Critical Design Review

Functional Overview (Cont'd)

Component	Operations System	"Test" System
SGI Origin 2000 server	1	1
SGI 02 workstation	2	1
X terminal	1	1
RAID (72 GB)	4	1
Network printer*	1*	1*
Color printer*	1*	1*

*shared device

NOTE: Any of the three SGI 02 workstations and two X terminals can be configured to support either the operations or the "test" system.

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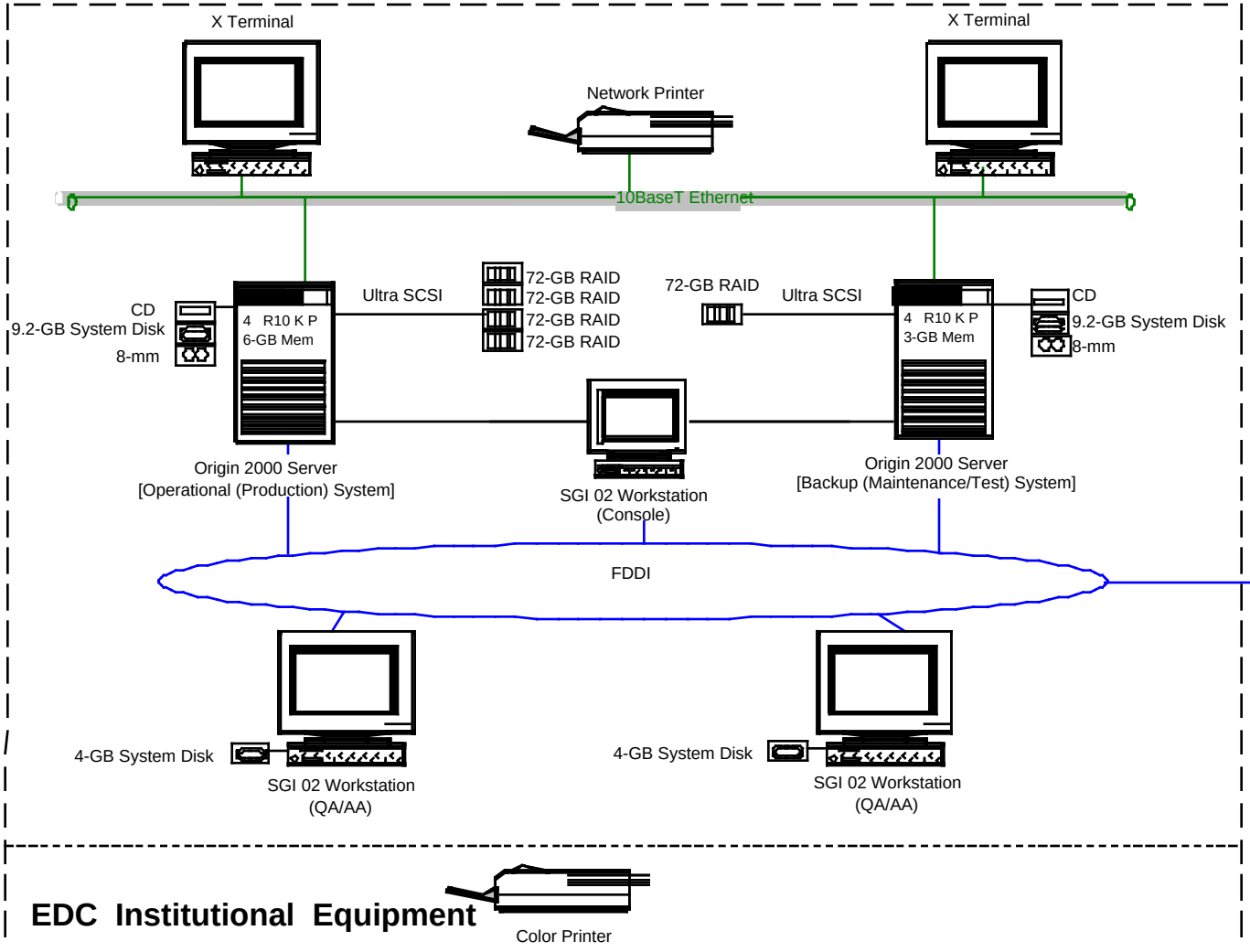
LPGS Critical Design Review

Current Architecture



Aug 12, 1997 KJ

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Current Architecture (Cont'd)

- SGI Origin 2000 servers (2)
  - Each server has
    - Four 195-MHz R10000 processors with 4-MB cache
      - Rack-mounted, expandable to 16 processors within a rack
    - 9.2-GB system disk
    - CD-ROM drive
    - 8-mm tape drive
    - RAM varies (6 GB on operational system; 3 GB on "test" system
    - Dual attached FDDI (100 Mbps peak)
    - SCSI III interfaces (40 MBps peak)
    - 10/100 BaseT Ethernet

LPGS Critical Design Review

Current Architecture (Cont'd)

Server Component	Operations System	"Test" System
Number of CPUs	4	4
RAM	6 GB	3 GB
System Disk	9.2 GB	9.2 GB

LPGS Critical Design Review

Current Architecture (Cont'd)

- SGI 02 workstations (3)
  - One used as system console
  - Others used for quality assessment and anomaly analysis
  - Each workstation has
    - Single 150-MHz R10000 processor
    - 4-GB system disk
    - 64-MB RAM
    - Dual attached FDDI (100 Mbps peak)
    - SCSI III interfaces (40 MBps peak)
    - 10/100 BaseT Ethernet
    - 20" color monitor (1280 x 1024 resolution)

LPGS Critical Design Review

Current Architecture (Cont'd)

- **X terminals (2)**
  - **Used by LPGS operator to monitor and control processing on operations and "test" systems**
  - **Connected to Origin 2000 server via Ethernet LAN**
- **RAID disk arrays**
  - **Used for storing images and associated data**
  - **Ciprico 6900 series supporting Ultra-SCSI interface at 40 MBps**
  - **72-GB capacity; five, for total storage of 360 GB**

LPGS Critical Design Review

Current Architecture (Cont'd)

- SCSI controllers
  - Used to connect CD-ROM, system disk, 8-mm tape drive
  - Multiple Ultra-SCSI controllers used to connect RAIDs to optimize disk I/O performance
- FDDI LAN
  - Connects operations and test systems with EDC DAAC
  - Rated at 100 Mbps
- Network printer
  - EDC institutional
- Color printer
  - EDC institutional
  - Type TBD

LPGS Critical Design Review

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LPGS Critical Design Review

Operational Scenarios

- LPGS processing flow
- Changes since SRR/SDR
- LPGS user types
- Current operational scenarios

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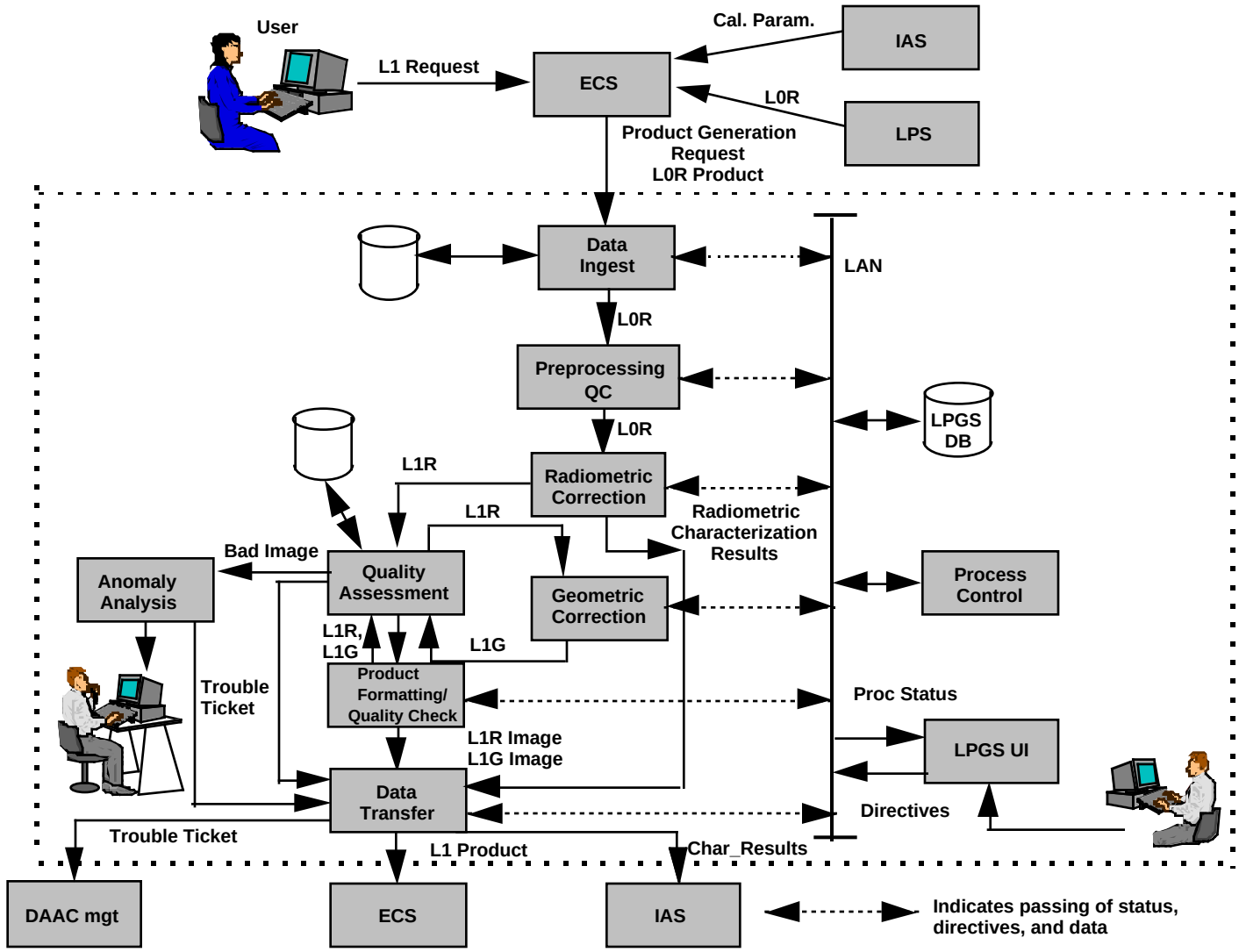
LPGS Processing Flow



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Changes Since SRR/SDR

- **Problem reporting (trouble tickets)**
  - **User reports problem via ECS; LPGS receives e-mail or phone notification; analyst accesses ECS' trouble ticket system**
  - **Unresolved problems diagnosed via AAS; trouble tickets made available to DAAC management**
- **Accounting information and statistics**
  - **Accounting information no longer exchanged with ECS**
  - **L1 production information not explicitly provided**

LPGS Critical Design Review

Changes Since SRR/SDR (Cont'd)

- **L1 product packaging**
  - **L1 products no longer "packaged" by ECS**
  - **LPGS to provide entire contents of L1 product to ECS**
    - **L1 products include consensus PCD/MSCD (2 formats combined to form a "value-added" file)**
  - **L1G FAST products to be distributed in FAST-C format**
  - **Quality (production) checks to be performed after packaging**
- **No automatic production cancellation**

LPGS Critical Design Review

LPGS User Types

User Type	Sample Functions
System operator	Initiate system startup and shutdown Configure system hardware and software Monitor system status
Production operator	Monitor L1 processing activities Manually modify WO Cancel product requests
Analyst (QA/AA)	Visually inspect images before distribution Resolve processing anomalies
DBA	General maintenance of database Performance monitoring of database Backup and recovery of database in event of catastrophic failure

LPGS Critical Design Review

LPGS User Types (Cont'd)

- An individual may assume responsibilities of multiple user-types
- Actual staffing profile to be determined by DAAC management

LPGS Critical Design Review

Current Operational Scenarios

1. Nominal activities
   - 1.1 Start up LPGS
   - 1.2 Shut down LPGS
   - 1.3 Process L1 product (nominal end-to-end processing flow)
   - 1.4 Cancel L1 processing
   - 1.5 Retrieval of characterization results by IAS

2. Non-nominal activities
   - 2.1 Analyze trouble ticket
   - 2.2 Process L1 product (non-nominal)
   - 2.3 Recover from LPGS failure
   - 2.4 Failover to backup system

LPGS Critical Design Review

Nominal Activities

1.1 Start Up LPGS

- **System operator**
  - Powers on/boots hardware
    - Oracle DBMS, etc., started
  - Logs onto operations interface workstation
  - Starts user interface
  - Selects option to start tasks
- **LPGS**
  - Starts background tasks
- **Production operator**
  - Displays LPGS event log
- **Analyst**
  - Logs onto QA/AA workstation
  - Displays relevant windows, tables

LPGS Critical Design Review

Nominal Activities (Cont'd)

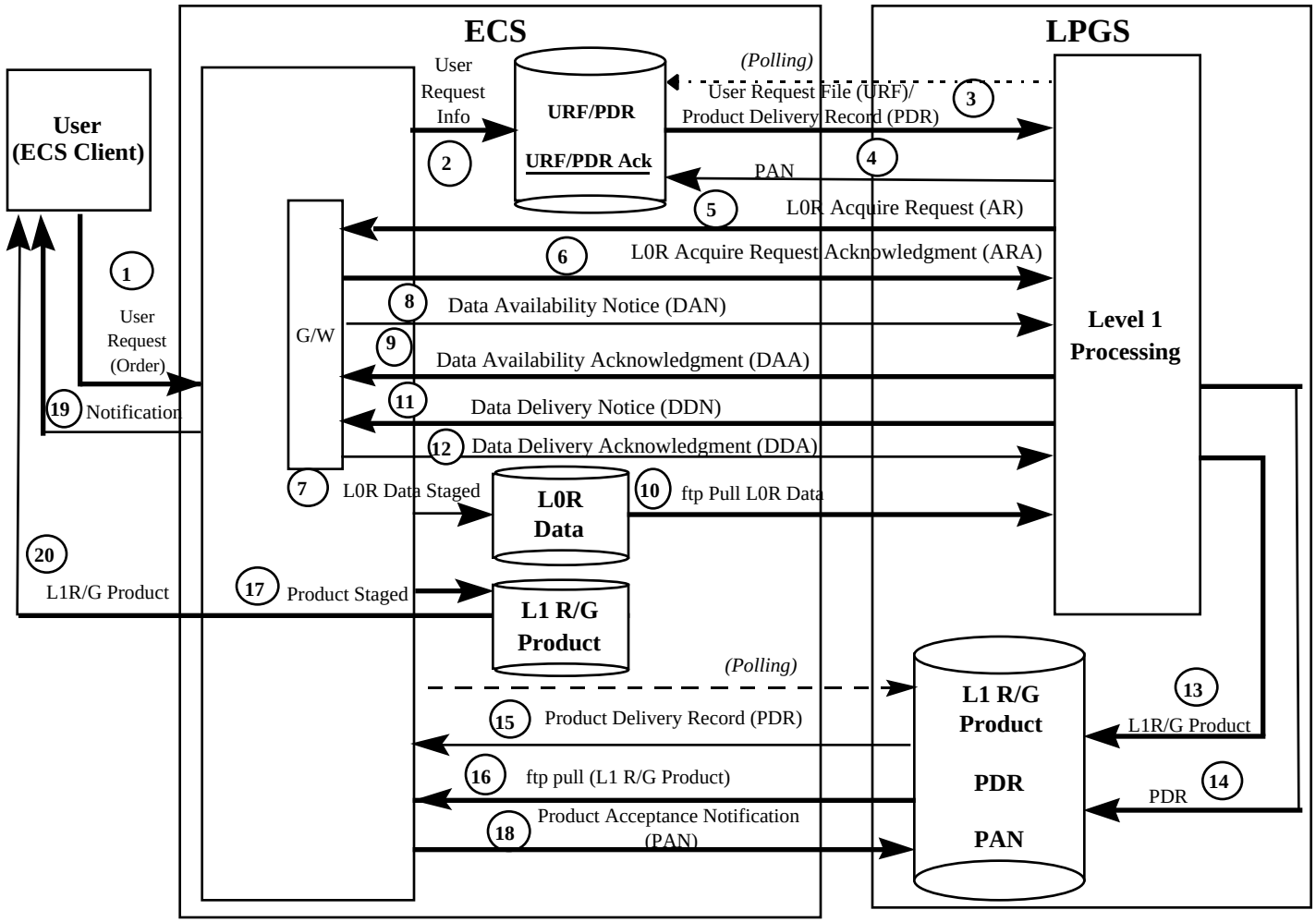
1.2 Shut Down LPGS

- **System operator** - Displays LPGS user interface, event log
- **Production operator** - Selects option to terminate tasks
- **LPGS** - Terminates current processing
- **Analyst** - Exits anomaly windows
  - Logs off QA/AA workstation
- **System operator** - Exits LPGS user interface
  - Terminates Oracle DBMS
  - Powers off workstations and monitors

LPGS Critical Design Review

Nominal Activities (Cont'd)

ECS/LPGS Interface for Distribution of L0R and L1 Products



Note: Authentication and TCP "open/close session" messages(via G/W) are intentionally not depicted.

LPGS Critical Design Review

Nominal Activities (Cont'd)

1.3 Process L1 Product—Nominal End-to-End Processing Flow

- **User** - Orders product via ECS client (1)
- **ECS** - Places L1 URF/PDR on ECS server (2)
- **LPGS** - Polls ECS server for new L1 URF/PDR (i.e., PR) (3)
  - Processes L1 PR
  - Sends L1 PAN via ftp (4)
  - Stores information in LPGS database
  - Assesses L0R product ingest criteria; indicates whether satisfied
  - Identifies next PR that needs L0R data
  - Sends start session message to establish TCP/IP socket connection
- **ECS** - Sends acknowledgment (successful connection)
- **LPGS** - Sends L0R AR (5)

LPGS Critical Design Review

Nominal Activities (Cont'd)

1.3 Process L1 Product—Nominal End-to-End Processing Flow (Cont'd)

- **ECS** - Sends L0R ARA (6)
- **LPGS** - Sends close session message to terminate TCP/IP socket connection
- **ECS** - Stages L0R product on ECS disk space (7)
  - Sends L0R DAN via ftp (8)
- **LPGS** - Processes new L0R DAN
  - Sends L0R DAA via ftp (9)
  - Retrieves L0R product via ftp (10)
  - Catalogs L0R files in database
  - Sends L0R DDN via ftp (11)
- **ECS** - Polls for new L0R DDN
  - Sends L0R DDA via ftp (12)

LPGS Critical Design Review

Nominal Activities (Cont'd)

1.3 Process L1 Product—Nominal End-to-End Processing Flow (Cont'd)

- **LPGS**
  - Processes new L0R DDA
  - Polls database for PRs ready for work order processing
  - Assesses available resources; starts processing when adequate
  - Performs L1 processing
    - Performs radiometric characterization/correction; assesses L1R results
    - Performs geometric characterization/correction; assesses L1G results
  - Formats and packages L1G product
  - Moves product to L1 delivery directory (13)
  - Sends PDR via ftp (14)

LPGS Critical Design Review

Nominal Activities (Cont'd)

1.3 Process L1 Product—Nominal End-to-End Processing Flow (Cont'd)

- **ECS**
  - Polls for PDR (15)
  - Retrieves L1 product via ftp (16)
  - Stages product for transfer (17)
  - Sends PAN (L1 product successfully retrieved) via ftp (18)
- **LPGS**
  - Processes PAN
  - Updates database (L1 product delivered; PR complete)
  - Updates deletion flag
- **ECS**
  - Notifies user (19)
  - Distributes L1 product to user (20)

LPGS Critical Design Review

Nominal Activities (Cont'd)

1.4 Cancel L1 Processing

- **ECS** - Verbally notifies operator of L1 product cancellation
- **Production operator/UI** - Displays status of applicable PR
  - Enters L1 product cancellation request
- **LPGS** - Stops processing; does not initiate execution of subsequent scripts that would normally be executed for L1 processing

LPGS Critical Design Review

Nominal Activities (Cont'd)

1.5 Retrieval of Characterization Results by IAS

- **IAS**
  - Connects to LPGS database via SQL*Net
  - Performs query to get changes since last retrieval
  - Retrieves characterization results since last retrieval
  - Updates trending flag for all PRs whose trending data have been retrieved
  - Disconnects from LPGS database
- **LPGS**
  - Deletes trending data associated with PR

LPGS Critical Design Review

Non-Nominal Activities

2. Non-nominal activities

   2.1 Analyze trouble ticket

   2.2 Process L1 product (non-nominal)

   2.3 Recover from LPGS failure

   2.4 Failover to backup system

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.1 Analyze Trouble Ticket

- **Analyst** - Receives notification by e-mail or phone that a new trouble ticket has been assigned to LPGS
- **Analyst/LPGS** - Via UI, accesses ECS trouble ticket system and queries for trouble ticket
  - If original product returned, copies product via ftp
  - Displays original image
- **Analyst** - Attempts to verify reported problem; views browse image and checks metadata
- **Analyst/LPGS** - If analyst wishes, reruns request
- **Analyst** - Visually examines product request, WO, WO log, event log, calibration file, quality assessment results, etc.

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.1 Analyze Trouble Ticket (Cont'd)

- **Analyst/LPGS**
  - Displays image
  - If additional run required, generates diagnostic WO
  - Visually inspects results
  - If problem resolved, records resolution, accesses ECS trouble ticket system to enter trouble ticket response
  - If source of problem not found, trouble ticket updated to indicate that LPGS was not the problem source; trouble ticket response made available to DAAC management

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.2 Process L1 Product—Non-nominal

- **LPGS**
  - L1 image fails automated quality assessment
  - Assesses results of L1R processing; finds anomaly
  - Sends message to operator/analyst (WO processing failed)
- **Analyst/LPGS**
  - Displays failed WO
  - Views event log, PR, WO, WO log, metadata, calibration files, L0R and L1R images
- **Analyst**
  - Develops plan for isolating problem (suspects systematic problem)
- **Analyst/LPGS**
  - Generates, runs benchmark WO
- **Analyst**
  - Confirms success of benchmark (sees local problem)

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.2 Process L1 Product—Non-nominal (Cont'd)

- **Analyst/LPGS - Generates, runs diagnostic WO**
- **Analyst - Detects cause of problem that appears correctable**
- **Analyst/LPGS - Generates diagnostic WO with necessary corrections**
- **LPGS - Runs diagnostic WO and delivers product**
- **Analyst/LPGS - Closes out anomaly**

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.3 Recover From LPGS Failure

- **LPGS**
  - LPGS process terminates abnormally (e.g., WO scheduler)
  - Notifies operator of unexpected termination
- **Production operator**
  - Displays PR processing status
  - Estimates processing impacts
- **System operator**
  - Notifies DAAC management/User Services of failure via voice communications; estimates processing impacts
- **Analyst**
  - Continues quality assessments, image analysis as much as possible

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.3 Recover From LPGS Failure (Cont'd)

- System/production - Follows operations procedures to resolve and operator recover from failure
- System operator - Notifies DAAC management/User Services of estimated time to return to full operations
- System/production operator - Resolves failure
- Production operator - Runs cleanup
- System operator - Restarts
  - Notifies DAAC management/User Services of return to full operations

2.4 Failover to Backup System

- **Assumes catastrophic failure of LPGS operations system hardware**
  - **Failure of prime operational system Origin 2000 server**
  - **Hardware anticipated down for several days (2 days)**
  - **Disk storage unaffected**

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.4 Failover to Backup System (Cont'd)

- **LPGS**
  - Hardware failure of prime operational system
  - All active processes and associated data lost
- **System operator**
  - Shuts down operational hardware
  - Notifies ECS, DAAC management, User Services of failure via voice communications; estimates processing impacts
    - Time until backup system (i.e., "test" system) becomes operational
    - Time until prime operational system is repaired and returned to full operations
  - Tells users on backup system to shut down, save work

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.4 Failover to Backup System (Cont'd)

- **DAAC management**
  - Enters trouble ticket into ECS trouble ticket system
  - Calls SGI maintenance for repair of operational system
- **System/production operator, DBA**
  - Reconfigures hardware for use on backup system
  - Reconfigures system software, etc., for use on backup system
  - Restarts backup system
  - Runs "known good" work order to confirm backup system performance
  - Assesses state of database to identify interrupted PRs
  - Sends new acquire requests for interrupted PRs

2.4 Failover to Backup System (Cont'd)

- **ECS** - Sends ARAs
- **System operator**
  - Cleans up from failure (deletes files)
  - Notifies ECS, DAAC management, User Services that backup system is online
- **LPGS**
  - Reprocesses interrupted PRs—standard flow resumed from ARA
  - Performs "reduced operations" in nominal fashion (less memory on backup system)
- **SGI maintenance** - Identifies problem(s), repairs prime operational system

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.4 Failover to Backup System (Cont'd)

- **DAAC management**
  - Notifies LPGS operator that prime operational system is repaired
  - Enters resolution into trouble ticket system
- **System operator**
  - Stops incoming requests to backup system
  - Allows PRs currently running on backup system to run to completion
  - Brings down backup system
  - Reconfigures hardware to support prime operational system
  - Restarts prime operational system

LPGS Critical Design Review

Non-Nominal Activities (Cont'd)

2.4 Failover to Backup System (Cont'd)

- LPGS
  - Runs "known good" WO to confirm operational system performance
  - Restarts backup system, notifies users
  - Notifies ECS, DAAC management, and User Services that prime operational system is available
  - Resumes nominal processing

LPGS Critical Design Review

■ Opening Comments	J. Henegar
■ System Overview	R. Hamilton
■ Hardware Architecture	K. Jeletic
■ Operational Scenarios	K. Jeletic
■ Level 1 Product Formats	L. Lindrose
■ Performance Analysis	W. Wang
■ LPGS Software Subsystem Design	
• Design Overview	B. Pedersen
• End-to-End Scenarios	B. Pedersen
• User Interface	O. Mechaly
• Data Management Subsystem	S. Beckwell
• Process Control Subsystem	B. Pedersen
• Radiometric and Geometric Processing Subsystems	B. Pedersen
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■ Conclusion	J. Henegar

LPGS Critical Design Review

Level 1 Product Formats

- LPGS output products
- LPGS file overview, formats summary, and naming convention
- Product formats
- Product contents

LPGS Critical Design Review

LPGS Output Products

- **Level 1R product—Radiometrically corrected but not geometrically resampled**
- **Level 1G product—Radiometrically corrected and resampled for geometric correction and registration to geographic map projections**
- **Output products fully described in *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Output Files Data Format Control Book (DFCB)*, August 1997**

LPGS Critical Design Review

LPGS File Overview

- Image data for each requested band is self-contained in a single file
- Mirror scan correction data (MSCD) contains first half scan error, second half scan error, and scan line direction
- Payload correction data (PCD) contains attitude and ephemeris profiles as well as high frequency jitter measurements
- Calibration parameter file (CPF) contains radiometric and geometric processing parameters required for L1 processing
- Internal calibrator (IC) file contains internal lamp and shutter data for bands 1 - 5, 7, and 8, and blackbody radiance and shutter data for band 6

LPGS Critical Design Review

LPGS File Overview (Cont'd)

- Geolocation index contains scene corner coordinates and product-specific scan line numbers for bands
- Scan line offsets contains actual starting and ending pixel positions for valid image data on a line-by-line basis
- Metadata contains subinterval- and scene-related information as well as product specific information

LPGS Critical Design Review

Key Terms

- **Scientific data set (SDS)—Array of data of any fixed dimensionality from 1 to 32767 and any one data type**
- **Vdata—Record-based structure where values are stored in fixed-length fields. Fields are defined, named, and typed individually. All records within a Vdata are identical in structure**
- **Vgroup—Structure for associating sets of data objects. Vgroups define logical relationships and may contain any HDF objects, including other Vgroups**
- **External element—Data that are stored in a separate file, external to the basic HDF file. External elements allow for products to be read without using the HDF library**

LPGS Critical Design Review

LPGS File Formats Summary

LPGS File	HDF Structure
Image data	SDS external elements; logically associated using the Vgroup data structure—Bands 1-5 and 7, Bands 6 low and 6 high, and Band 8
Mirror scan correction data	Vdata table
Payload correction data	Vdata table
Calibration parameter file	Vdata table composed of three ASCII character strings; follows ODL syntax
Internal calibrator data	SDS external elements
Geolocation index	Vdata
Scan line offsets	Vdata tables
Metadata	Vdata table with one long ASCII character string; follows ODL syntax

LPGS Critical Design Review

LPGS File Naming Convention

Filename: L7XsssfnYYDOYHHuuv_aaa.file extension

L7	=	Landsat 7 mission
X	=	Landsat 7 X-band (1, 2, or 3)
sss	=	ground station (e.g., EDC)
f	=	ETM+ data format
		= 1, format 1 data
		= 2, format 2 data
n	=	LPS processor number (1 - 9)
YY	=	last 2 digits of year associated with contact period
DOY	=	day of year associated with contact period (001 through 366)
HH	=	hour of contact period within 24-hour day (00 - 23)
uu	=	subinterval within contact period (00 - 99)

LPGS Critical Design Review

LPGS File Naming Convention (Cont'd)

v = dataset version number
= 0, original
= 1- 9, reprocessed data

aaa = file type
= B10, B20, etc. for band files
= CAL for IC data
= MTL for LPGS metadata
...

file extension = YYDOYHHMM for ECS-generated files
where YYDOYHHMM = system clock time product was generated
= xxx, for LPGS-generated files
where L1R = files included with an L1R product
L1G = files included with an L1G product

LPGS Critical Design Review

Product Formats

- **L1R product**
  - **HDF-EOS unencapsulated**
- **L1G product**
  - **HDF-EOS unencapsulated**
  - **FAST-C**
  - **GeoTIFF**

LPGS Critical Design Review

Product Contents—L1R

L1R Product—HDF-EOS Unencapsulated

- Image data
  - Each file contains one band of image pixels in 16-bit unsigned integers
- Consensus MSCD
  - Subsetted according to product ordered
- Consensus PCD
- Calibration parameter file
- Internal calibrator data
  - Format 1 for products that include bands 1 through 6 low
  - Format 2 for products that include bands 6 high through 8
  - Subsetted according to the product ordered

LPGS Critical Design Review

Product Contents—L1R (Cont'd)

L1R Product—HDF-EOS Unencapsulated (Cont'd)

- Geolocation index
- Scan line offsets
  - Format 1 for products that include bands 1 through 6 low
  - Format 2 for products that include bands 6 high through 8
  - Subsetted according to the product ordered
- LPS metadata
  - Format 1 and Format 2 will be included with all L1R products
- LPGS metadata

LPGS Critical Design Review

Product Contents—L1G

L1G Product—HDF-EOS Unencapsulated

- **Image data**
  - **Each file contains one band of image pixels in 8-bit unsigned integers**
- **LPGS metadata**

LPGS Critical Design Review

Product Contents—L1G

L1G Product—FAST-C

- **Header file**
  - **Administrative record contains information identifying product, image, and data needed to ingest image data**
  - **Radiometric record contains coefficients needed to convert image digital values into at-satellite spectral radiance**
  - **Geometric record contains image geodetic location information needed to align imagery to other data sources**
- **Image data**
  - **Each file contains one band of image pixels in 8-bit unsigned integers**

LPGS Critical Design Review

Product Contents—L1G

L1G Product—GeoTIFF

- File
  - All requested bands of image data in 8-bit unsigned integers
  - Metadata
- Products cannot be ordered in the following projections:
  - Space Oblique Mercator (SOM)
  - Oblique Mercator Type A (OMA)

LPGS Critical Design Review

Product Contents—LPGS Metadata

- Included with the HDF-EOS unencapsulated L1R and L1G products
- Contains
  - HDF directory
  - Filenames
  - Band combination
  - Product path and row
  - Product corners
  - Gains
  - Corrections applied
  - Minimum and maximum detected radiance
  - Datum*
  - Ellipsoid*
  - Grid cell size*
  - Orientation*
  - Resampling method*
  - Map projection*
  - Projection parameters*

*L1G product only

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LPGS Critical Design Review

Performance Analysis

- Analysis approach
- Modeled LPGS hardware configuration
- Assumptions/basis of estimate
- Analysis results
- Timing for ECS/LPGS interface
- Summary

Reference: ***LPGS Performance and Sizing Estimates*** **(June 1997)**
http://lpgs-server.gsfc.nasa.gov

LPGS Critical Design Review

Analysis Approach

- Based on current LPGS and IAS designs
- Instruction counts estimated from algorithms and prototype code for radiometric processing
- Instruction counts converted into CPU times for radiometric performance
- Geometric performance extrapolated from EDC prototype results
- Data volumes (for both storage and transfer) estimated for each of major functions
- Elements considered
  - CPU time
  - Disk I/O
  - FDDI data transfer
  - Storage (disk, memory)

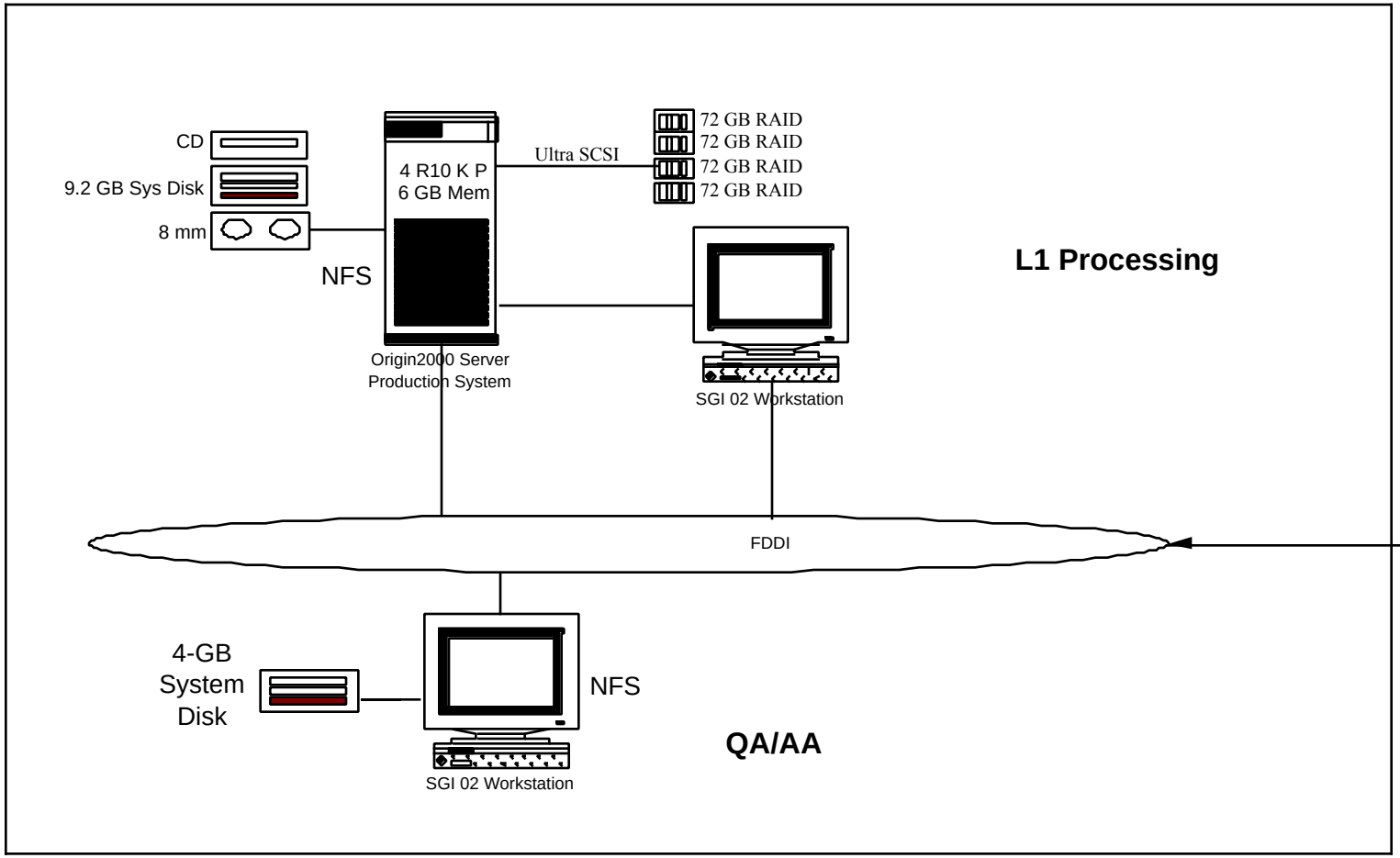
LPGS Critical Design Review

Analysis Approach (Cont'd)

- **Workload requirements as specified in F&PRS**
  - **Retrieval, processing, and delivery of 25 WRS scenes per day**
  - **10 percent reprocessing (3 WRS scenes per day)**
- **Only operations system addressed**
- **MS Excel spreadsheet model and a discrete event/analytical model using QASE developed for analysis**

LPGS Critical Design Review

Modeled LPGS Hardware Configuration



LPGS Critical Design Review

Assumptions/Basis of Estimate

- **Hardware configuration**
  - **Origin 2000, R10000 processor, 195 MHz (4 processors)**
  - **Origin 02 workstation: 150 MHz**
  - **FDDI data transfer rate: 60 Mbps**
  - **Concatenated RAID I/O: 70 MBps**
  - **CPU overhead during FDDI data transfer: 20%**
  - **Number of CPU cycles for disk data transfer: 2 cycles/byte**
  - **Processor degradation for 4 processors: 7%**
- **2 CPU cycles per instruction for radiometric processing (equivalent to 97.5 MFLOPS for R10000)**
- **Geometric processing (for 1 WRS scene)**
  - **180 seconds of CPU time for band 1/2/3/4/5/7 data (prototype results from geometric prototyping)**
  - **720 seconds of CPU time for band 8**
  - **135 seconds of CPU time for band 6**

LPGS Critical Design Review

Assumptions/Basis of Estimate (Cont'd)

- Error margin
  - Instruction count estimate for radiometric processing: 50%
  - Disk I/O, FDDI data transfer: 10%
  - Storage (disk, memory): 5%
- Additional reserve per F&PRS
  - Memory: 25%
  - Disk storage: 25%
- Intertask messages insignificant compared with size of images and therefore not modeled
- Average scene size of 1 WRS scene used as basis for analysis
- Image size
  - L1G image: 1 byte/pixel
  - L1R image: 2 bytes/pixel

LPGS Critical Design Review

Analysis Results

Total Service Time for One WRS Scene

(in minutes)	Ingest Data	L1R Processing	L1G Processing	Format Product	Transfer Product	Total
CPU Time						
Application	negligible	50.17	32.25	negligible	negligible	82.42
FDDI O/H	0.26	0.00	0.00	0.00	0.51	0.77
RAID O/H	0.30	2.02	0.87	0.57	0.20	3.96
Subtotal	*0.56*	*52.19*	*33.12*	*0.57*	*0.71*	*87.15*
Data Transfer Time						
FDDI	1.19	0.00	0.00	0.00	2.39	3.58
RAID	0.38	2.62	1.12	0.73	0.26	5.11
Subtotal	*1.57*	*2.62*	*1.12*	*0.73*	*2.65*	*8.69*
Total	**2.13**	**54.81**	**34.24**	**1.30**	**3.36**	**95.84**

Service Time: Amount of time resource is active for a given process.

LPGS Critical Design Review

Analysis Results (Cont'd)

Service Time by Band for One WRS Scene

(in minutes)	Ingest Data	L1R Processing	L1G Processing	Format Product	Transfer Product	Total
CPU Time						
Band 1/2/3/4/5/7		4.24	3.09			7.33
Band 6		1.17	2.29			3.46
Band 8		25.66	12.33			37.99
All Bands	0.56			0.57	0.71	1.84
Data Transfer Time						
Band 1/2/3/4/5/7		0.27	0.11			0.38
Band 6		0.08	0.06			0.14
Band 8		1.02	0.43			1.45
All Bands	1.57			0.73	2.65	4.95

LPGS Critical Design Review

Analysis Results (Cont'd)

Resource Utilization (4 Processors) (24 Hours)

Resources	Nominal Processing 28 WRS Scenes a Day (including reprocessing of 3 WRS scenes)	Non-nominal Processing 3 WRS Scenes a Day (Benchmark & Diagnostic Runs only)	Total
L1 Processor HWCI			
CPU (4 CPUs)	42.36%	9.53%	51.89%
FDDI	6.96%	6.04%	13.00%
Disk I/O	9.94%	2.78%	12.72%

LPGS Critical Design Review

Analysis Results (Cont'd)

Memory and Disk Space Requirements

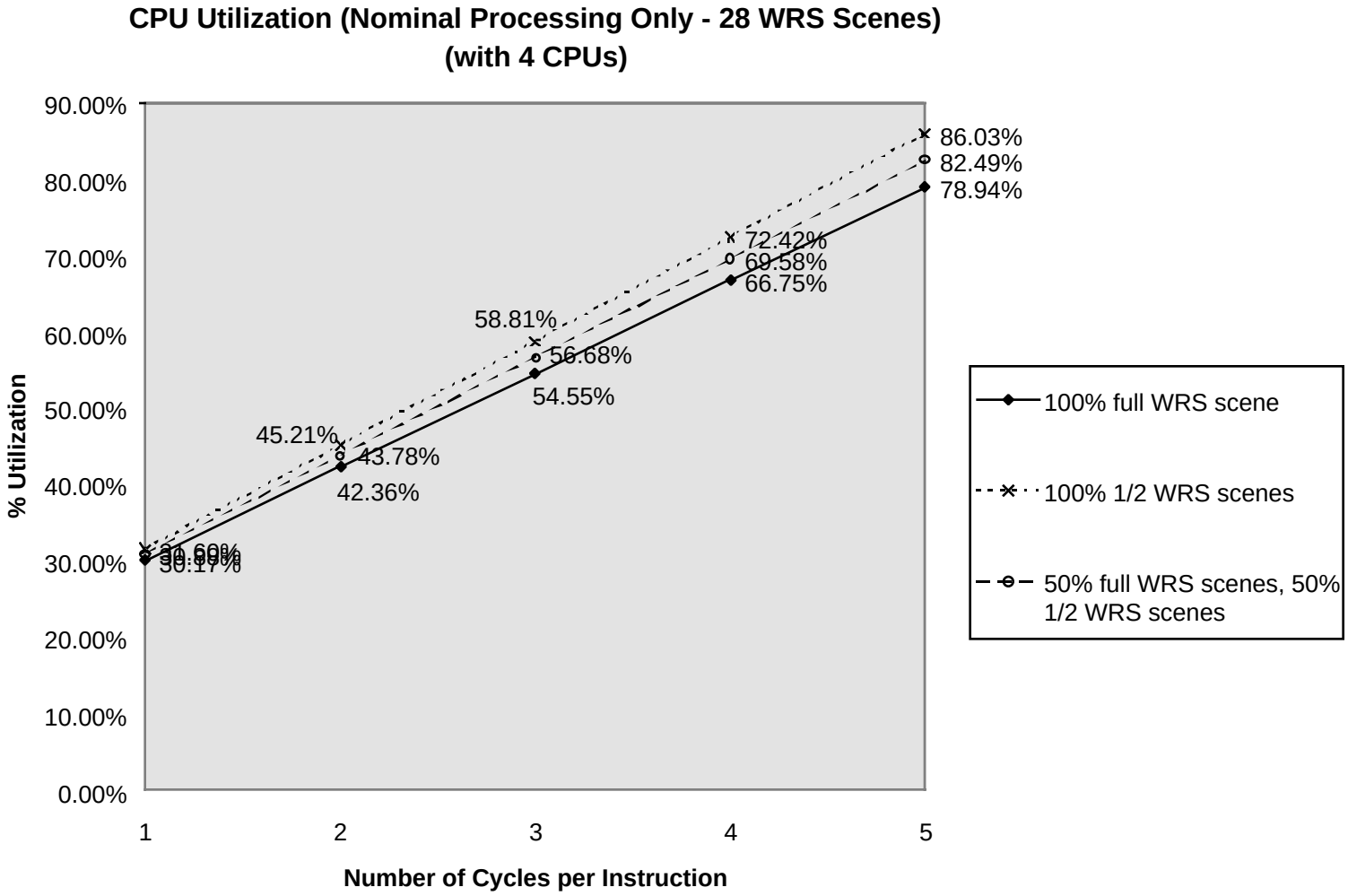
	Required Amount (including 25% reserve)	Baseline
Memory	1.39 GB/processor 5.56 GB total	6.0 GB total
Disk	249 GB total	288 GB total

NOTE: Memory requirement driven by radiometric processing

MO&DSD
CODE 500

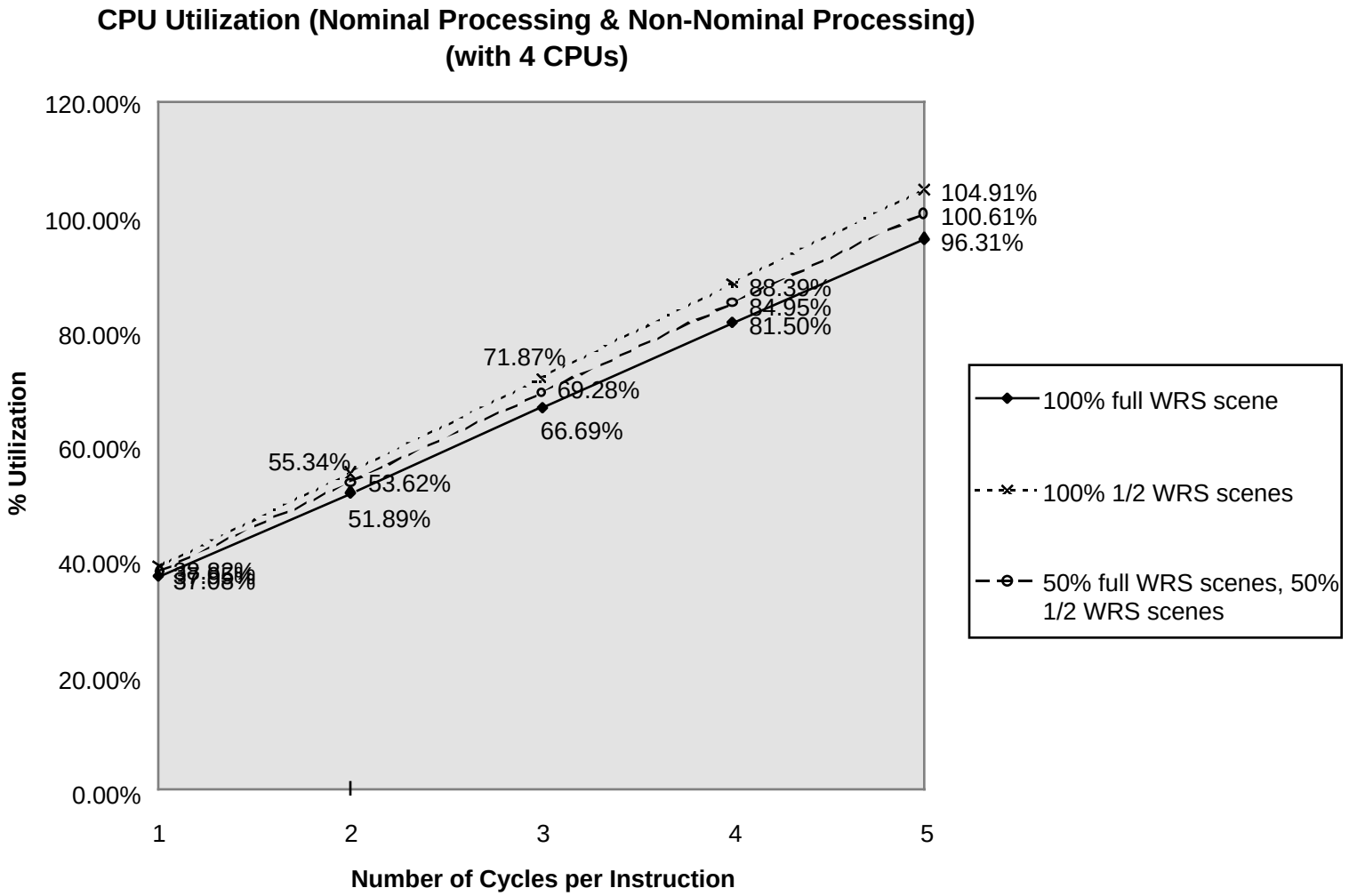
LPGS Critical Design Review

Sensitivity Analysis Results



LPGS Critical Design Review

Sensitivity Analysis Results (Cont'd)



LPGS Critical Design Review

Timing for ECS/LPGS Interface

- **Staging of L0R products for LPGS by ECS**
  - **ECS model results indicate average turnaround time**
    - **1/2 hour during graveyard shift (midnight to 8 am)**
    - **3 hours during 2nd shift (4 pm to midnight)**
  - **LPGS idle time can be minimized if disk space for input directories sufficient for 6 to 9 scenes and 4 product requests being processed simultaneously**
- **L1 product retrieval by ECS**
  - **ECS will transfer L1 product as soon as request is received if priority for LPGS ingest is high**
  - **LPGS disk space for product delivery directory is sufficient for 12 scenes**
  - **Not a concern if priority for LPGS ingest is high**
- **Other messages and message responses**
  - **Turnaround times in the order of seconds, not a concern**

LPGS Critical Design Review

Summary

- Resource utilization reasonable based on current assumptions
- Plan to process at least 4 product requests simultaneously to use resources fully
- Using 4 processors to process 4 product requests simultaneously, LPGS can process 4 WRS scenes in about 110 minutes (taking into consideration I/O contention among 4 PRs)
- LPGS can process 28 WRS scenes in 13 hours
- Turnaround timing of L0R by ECS (1/2 - 3 hours) supports LPGS throughput requirements and therefore not a concern
- Will continue to update model to reflect prototype/test results

LPGS Critical Design Review